CIVIL ENGINEERING

ESE TOPICWISE OBJECTIVE SOLVED

PAPER-I

1995-2024

IES MASTER PUBLICATION

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First Edition	**:**	**2016**
Second Edition	**:**	**2017**
Third Edition	**:**	**2018**
Fourth Edition	**:**	**2019**
Fifth Edition	**:**	**2020**
Sixth Edition	**:**	**2021**
Seventh Edition	**:**	**2022**
Eighth Edition	**:**	**2023**
Ninth Edition	**:**	**2024**

Typeset at : IES Master Publication, New Delhi-110016

PREFACE

Engineering Services Examination (ESE) is the gateway to an immensely satisfying job in the engineering sector of India that offers multi-faceted exposure. The exposure to challenges and opportunities of leading the diverse field of engineering has been the main reason behind engineering students opting for Engineering Services as compared to other career options. To facilitate selection into these services, availability of numerical solution to previous years' paper is the need of the day.

It is an immense pleasure to present previous years' topic-wise objective solved papers of ESE. The revised and updated edition of this book is an outcome of regular and detailed interaction with the students preparing for ESE every year. The book includes solutions along with detailed explanation to all the questions. The prime objective of bringing out this book is to provide explanation to each and every question in such a manner that just by going through the solutions, ESE aspirants will be able to understand the basic concepts, and have the capability to apply these concepts in solving other questions that might be asked in future exams. Towards this end, this book becomes indispensable for every ESE aspiring candidate.

IES Master Publication
New Delhi

CONTENT

1 STRENGTH OF MATERIALS

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1. Given that for an element in a body of homogeneous isotropic material subjected to plane stress; $\varepsilon_x, \varepsilon_y$ and ε_z are normal strains in x, y, z directions respectively and μ is the Poisson's ratio, the magnitude of unit volume change of the element is given by

(a) $\varepsilon_x + \varepsilon_y + \varepsilon_z$ (b) $\varepsilon_x - \mu\,(\varepsilon_y + \varepsilon_z)$

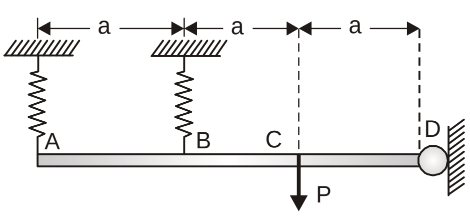
(c) $\mu\,(\varepsilon_x + \varepsilon_y + \varepsilon_z)$ (d) $1/\varepsilon_x + 1/\varepsilon_y + 1/\varepsilon_z$

2. A solid metal bar of uniform diameter D and length L is hung vertically from a ceiling. If the density of the material of the bar is ρ and the modulus of elasticity is E, then the total elongation of the bar due to its own weight is

(a) $\rho L / 2E$ (b) $\rho L^2 / 2E$

(c) $\rho E / 2L$ (d) $\dfrac{\rho E}{2L^2}$

3. A rigid beam ABCD is hinged at D and supported by two springs at A and B as shown in the given figure. The beam carries a vertical load P at C. The stiffness of spring at A is 2K and that of B is K.

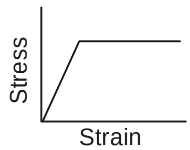


The ratio of forces of spring at A and that of spring at B is

(a) 1 (b) 2

(c) 3 (d) 4

4. The stress-strain curve for an ideally plastic material is

(a)


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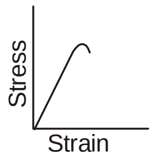

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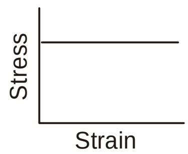

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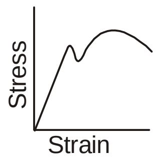


5. A steel cube of volume 8000 cc is subjected to an all round stress of 1330 kg/sq. cm. The bulk modulus of the material is 1.33×10^6 kg/sq. cm. The volumetric change is

(a) 8 cc (b) 6 cc

(c) 0.8 cc (d) 10^{-3} cc

6. In terms of bulk modulus (K) and modulus of rigidity (G), the Poisson's ratio can be expressed as

(a) (3K – 4G)/(6K+4G) (b) (3K+4G)/(6K– 4G)

(c) (3K – 2G)/(6K+ 2G) (d) (3K+2G)/(6K – 4G)

7. Two bars one of material A and the other of material B of same length are tightly secured between two unyielding walls. Coefficient of thermal expansion of bar A is more than that of B. When temperature rises the stresses induced are

(a) tension in both materials

(b) tension in material A and compression in material B

(c) compression in material A and tension in material B

(d) compression in both materials

8. A column of height 'H' and area at top 'A' has the same strength throughout its length, under its own weight and applied stress 'P_0' at the top. Density of column material is 'ρ'. To satisfy the above condition, the area of the column at the bottom should be.

(a) $Ae^{\left(\frac{HP_0}{\rho g}\right)}$ (b) $Ae^{\left(\frac{-\rho gH}{P_0}\right)}$

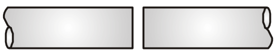
(c) $Ae^{\left(\frac{\rho gH}{P_0}\right)}$ (d) $Ae^{\left(\frac{H}{\rho gP_0}\right)}$

9. A bar of diameter 30 mm is subjected to a tensile load such that the measured extension on a gauge length of 200 mm is 0.09 mm and the change is diameter is 0.0045 mm. The Poisson's ratio will be

(a) 1/4 (b) 1/3

(c) 1/4.5 (d) 1/2

10. When a mild-steel specimen fails in a torsion-test, the fracture looks like

(a) 

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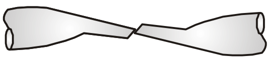
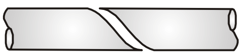
(c) 

(d) 

11. A 2 m long bar of uniform section 50 mm^2 extends 2 mm under a limiting axial stress of 200 N/mm^2. What is the modulus of resilience for the bar?

(a) 0.10 units (b) 0.20 units

(c) 10000 units (d) 200000 units

12. The stress level, below which a material has a high probability of **not** failing under reversal of stress, is known as

(a) elastic limit (b) endurance limit

(c) proportional limit (d) tolerance limit

13. If E = 2.06 × 10^5 N/mm^2, an axial pull of 60 kN suddenly applied to a steel rod 50 mm in diameter and 4 m long, causes an instantaneous elongation of the order of

(a) 1.19 mm (b) 2.19 mm

(c) 3.19 mm (d) 11.9 mm

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14. A bar of circular cross-section varies uniformly from a cross-section 2D to D. If extension of the bar is calculated treating it as a bar of average diameter, then the percentage error will be

(a) 10 (b) 25

(c) 33.33 (d) 50

15. The length, coefficient of thermal expansion and Young's modulus of bar 'A' are twice that of bar 'B'. If the temperature of both bars is increased by the same amount while preventing any expansion, then the ratio of stress developed in bar A to that in bar B will be

(a) 2 (b) 4

(c) 8 (d) 16

16. The lists given below refer to a bar of length L, cross sectional area A, Young's modulus E, Poisson's ratio μ and subjected to axial stress 'p'. Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I	List-II
A. Volumetric strain	**1.** $2(1+\mu)$
B. Strain energy per unit volume	**2.** $3(1-2\mu)$
C. Ratio of Young's modulus to bulk modulus	**3.** $\frac{p}{E}(1-2\mu)$
D. Ratio of Young's modulus to modulus of rigidity	**4.** $\frac{p^2}{2E}$
	5. $2(1-\mu)$

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	5	4	1	2
(c)	5	4	2	1
(d)	2	3	1	5

17. If all dimensions of prismatic bar of square cross-section suspended freely from the ceiling of a roof are doubled then the total elongation produced by its own weight will increase

(a) eight times (b) four times

(c) three times (d) two times

EXPLANATIONS

1. (a) Unit volume change,

$$\frac{\Delta V}{V} = \frac{\text{Final volume} - \text{Initial volume}}{\text{Initial volume}}$$

$$\frac{\Delta V}{V} = \frac{(1+\varepsilon_x)(1+\varepsilon_y)(1+\varepsilon_z)-1}{1}$$

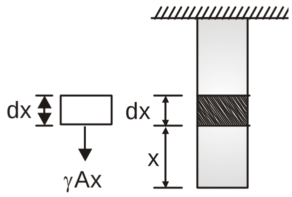
$$= 1 + \varepsilon_x + \varepsilon_y + \varepsilon_z + \varepsilon_x\varepsilon_y + \varepsilon_y\varepsilon_z + \varepsilon_z\varepsilon_x + \varepsilon_x\varepsilon_y\varepsilon_z - 1$$

product of strain terms are very small, so neglecting them

hence $\frac{\Delta V}{V} = \varepsilon_x + \varepsilon_y + \varepsilon_z$

2. (b) Elongation in length, dx is $d\delta$

$$d\delta = \frac{Pdx}{AE} \text{ for a force of P on element (dx)}$$



$$\int d\delta = \int_0^L \frac{Ax\,\gamma\,dx}{AE}$$

$$\delta = \int_0^L \frac{\gamma}{E}\frac{x^2}{2}$$

$$= \frac{\gamma L^2}{2E}$$

$$\delta = \gamma\int_0^L \frac{x^2}{2E} = \frac{\gamma L^2}{2E}$$

Alternative

The elongation of bar due to its own weight (w) is

$$\Delta = \frac{WL}{2AE} = \frac{(\gamma AL)\cdot L}{2AE}$$

$$\Delta = \frac{\gamma L^2}{2E}$$

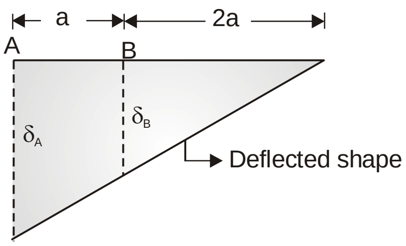
3. (c) Given, $K_A = 2K_B$

Force carried by spring at A

$$= F_A = k_A\delta_A \Rightarrow 2k_B\delta_A$$

Force carried by spring at B

$$= F_B = k_B\delta_B$$



From similar triangles

$$\frac{\delta_A}{3a} = \frac{\delta_B}{2a} \Rightarrow \delta_A = 1.5\delta_B$$

$$\frac{F_A}{F_B} = \frac{2k_B\delta_A}{k_B\delta_B} = \frac{2\delta_A}{\delta_B} = \frac{2\times1.5\delta_B}{\delta_B} = 3$$

4. (c) An ideal plastic material experiences no elastic deformation.

5. (a)

$$\text{Bulk modulus} = \frac{-P}{\Delta V/V}$$

$$1.33\times10^6 = -\frac{1330}{\Delta V/8000}$$

$$\Delta V = -8 \text{ cc}$$

(–) ve sign indicates reduction in volume if stress is compressive in nature.

6. (c) We know,

$$E = 2G(1+\mu) \quad \text{... (i)}$$

$$E = 3K(1-2\mu) \quad \text{... (ii)}$$

(where μ is poisson's ratio)

Equation (i) $\div$ (ii)

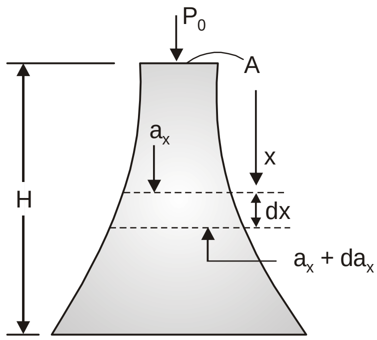
$$1 = \frac{2}{3}\frac{G}{K}\frac{(1+\mu)}{(1-2\mu)}$$

$$3K - 6K\mu = 2G + 2G\mu$$

$$\mu = \frac{3K-2G}{6K+2G}$$

7. (d) As the temperature rises, both the bars will have tendency to expand but they are fixed between two unyielding walls so they will not be allowed to expand. Hence in both the bars compressive stress will develop.

8. (c)



As we move down weight of column will add up to produce stresses. Since the column has same strength, so to satisfy the condition, the X-sectional area must increase as we move down

Let area at distance x be a_x and in length dx

$$\text{wt, added} = \rho g a_x dx$$

But stress has to remain constant